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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)

SUMMER FLOUNDER

Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

Fish and Wildlife Service
U.S. Department of the Interior

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)

SUMMER FLOUNDER

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PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

A Habitat Suitability Index (HSI) model is being prepared by the U.S. Fish and Wildlife Service for the summer flounder. HSI models are designed to provide a numerical index of the relative value of a given site as fish or wildlife habitat.

Suggestions or questions regarding this report should be directed to:

Information Transfer Specialist
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CONVERSION FACTORS

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
kilometers (km)	0.6214	miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (mt)	2205.0	pounds
metric tons	1.102	short tons
kilocalories (kcal)	3.968	BTU
Celsius degrees	1.8(C°) + 32	Fahrenheit degrees

U.S. Customary to Metric

inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
acres	0.4047	hectares
square miles (mi^2)	2.590	square kilometers
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
short tons (ton)	0.9072	metric tons
BTU	0.2520	kilocalories
Fahrenheit degrees	0.5556(F° - 32)	Celsius degrees

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We are grateful for the technical reviews by Stuart Wilk, National Marine Fisheries Service, Sandy Hook, New Jersey, and by Dr. Tim Targett, Skidaway Institute of Oceanography, Savannah, Massachusetts.

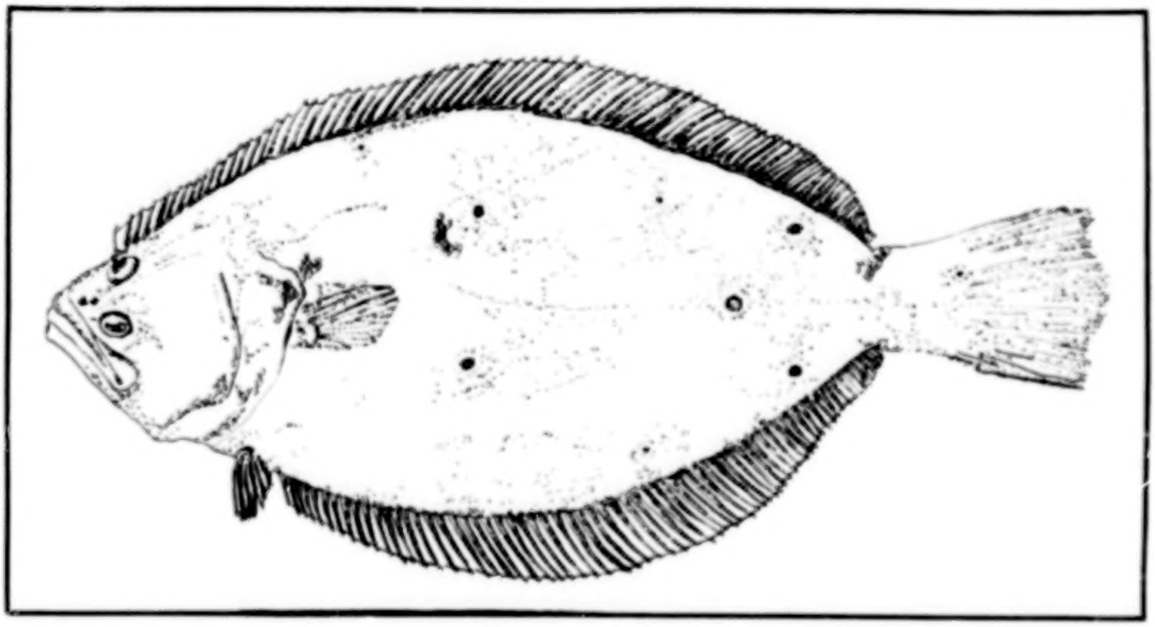

Figure 1. Summer flounder (adapted from Powell 1974).

SUMMER FLOUNDER

NOMENCLATURE/TAXONOMY/RANGE

Scientific name . . . . . Paralichthys dentatus (Linnaeus)
Preferred common name . . . . . Summer flounder (Robins et al. 1980, Figure 1)
Other common names . . . . . Flounder, fluke, plaice fish, plaice, plaise, splaice, chicken halibut, brail, turbot, flatfish, long-toothed flounder, flounder of New York, common flounder
Class . . . . Osteichthyes
Order . . . . Pleuronectiformes
Family . . . . . . Bothidae - lefteye flounders

Geographic range: The summer flounder is found in estuarine and shelf waters from Nova Scotia to the Atlantic coast of south Florida (Leim and Scott 1966; Gutherz 1967); it may occur in the Gulf of Mexico (Poole 1962; Topp and Hoff 1972; Wilk et al. 1980). Abundance is greatest between Cape Cod, Massachusetts, and Cape Hatteras, North Carolina (Figure 2). The species formerly was more abundant north of Cape Cod than at present (Bigelow and Schroeder 1953).

MORPHOLOGY/IDENTIFICATION AIDS

The following description was provided by Gutherz (1967): dorsal rays, 80-98; anal rays, 60-78; pectoral rays, 10-13; gill rakers on upper arch, 3-7; gill rakers on lower arch 13-18; body laterally flattened with margin of preopercle free and eyes on left side as in other bothids;

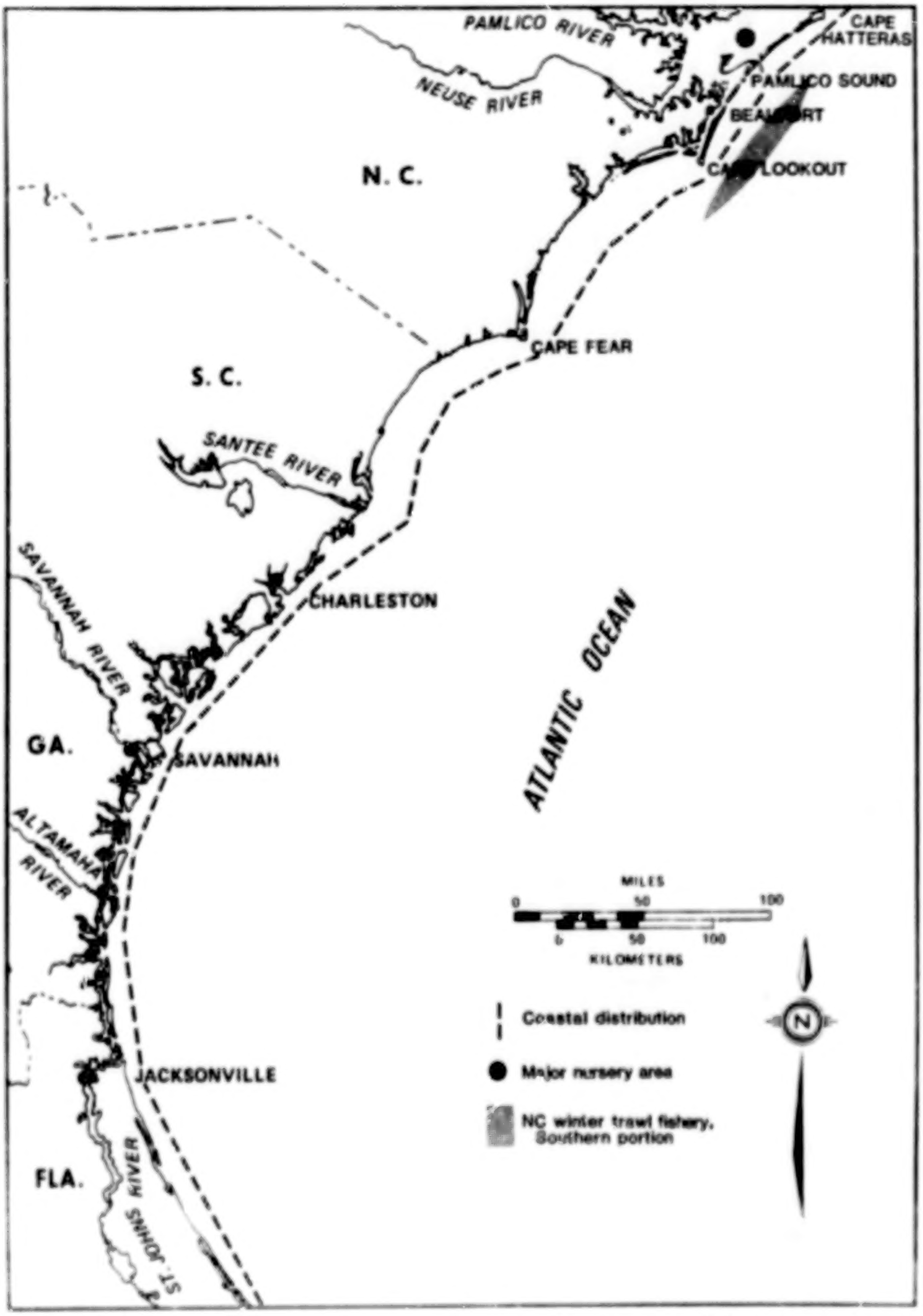

Figure 2. Distribution of summer flounder in the South Atlantic region.

bases of both pelvic fins short. Summer flounder longer than 18 mm standard length (SL) can be separated from southern flounder (P. lethostigma) and gulf flounder (P. albigutta) by using gill raker counts (P. dentatus usually has more than 14 rakers on lower arch) and sometimes by body coloration. Specimens shorter than 18 mm SL can be separated from southern and gulf flounders by using vertebrae counts (40-42 for summer flounder, fewer than 38 for others) and pigment patterns (Deubler 1958). Detailed descriptions of summer flounder developmental stages are in Martin and Drewry (1978).

Color in life: ocular side is tannish to dark brown with numerous ocellated spots, five of which are arranged in two triangles with a common apex on the lateral line. Spots generally are absent in larger specimens. Paralichthys spp. can readily match the apparent texture and, to a lesser degree, the color of bottom substrates on which they live.

REASON FOR INCLUSION IN SERIES

The summer flounder is an important commercial and recreational fish along the Atlantic seaboard of the United States, but the commercial fishery is not substantial in the South Altantic Bight (south of Cape Hatteras to Florida). The Pamlico Sound estuarine complex in North Carolina is believed to be a major nursery area for young from the Middle Atlantic (Cape Hatteras northward to Cape Cod) and South Atlantic stocks, but this is uncertain because little is known about dispersal. The eventual contribution of fish using smaller nursery areas scattered along the South Atlantic Bight to adult stocks along other portions of the Atlantic coast is not known.

LIFE HISTORY

Terminology used to describe life history stages conforms to that used by Martin and Drewry (1978).

Adult Spawning and Migration

Spawning times and habitats of summer flounder in the South Atlantic Bight are poorly documented. Available information consists of limited offshore collections of newly hatched larvae (Smith 1973), observations of reproductive cycles at Beaufort and Pamlico Sound, North Carolina (Hildebrand and Schroeder 1928; Powell 1974), and seasonality of newly arrived young in estuaries (Deubler 1958; Tagatz and Dudley 1961; Burns 1974; Cain and Dean 1976; Weinstein 1979; Bozeman and Dean 1980; Weinstein et al. 1980a, 1980b). Seasonal migration patterns of adult fish have been deduced from (1) collections of newly hatched larvae (which provide information only on the reproducing segment of the population); (2) commercial catch rates in the Cape Hatteras area; and (3) generalized coastal and shelf trawling surveys (Pearson 1932; Nesbit and Neville 1935; Anderson and Gehringer 1965; Anderson 1968; Dahlberg and Odum 1970; Smith 1973; Turner and Johnson 1973; Wilk and Silverman 1976; Wenner et al. 1979a,b, c,d, 1980). The studies cited above plus information from the Middle Atlantic Bight on seasonality of the commercial catch (Pearson 1932; Nesbit and Neville 1935; Eldgridge 1962) and tagging studies (Poole 1962; Murawski 1970; Lux and Nichy 1981) provide data that may be applicable to populations in the South Atlantic Bight. It should be recognized, however, that subpopulations north and south of Cape Hatteras may be genetically distinct, a possibility which could lead to differences in behavior, habitat requirements, and other factors (see THE FISHERY section).

Adult summer flounder spend the warmer months in nearshore shelf waters and coastal embayments. They migrate offshore during cooler months and spawn during late fall, winter, or early spring on or near the bottom in shelf waters ranging from 30 to 200 m deep. Summer flounder begin a spawning migration as they near the peak of their gonadal development cycle, with the oldest and largest fish migrating first each year (Morse 1981).

The major spawning period in the waters between Virginia and Cape Lookout, North Carolina, begins in November and continues for 2 or 3 months; newly hatched larvae have been collected in the open shelf waters of the South Atlantic Bight in late January and early February (Smith 1973). In the Middle Atlantic Bight, the spawning cycle and offshore limits of migration are strongly correlated with the fall-winter cooling of coastal waters and with the inshore limits of cold bottom water intrusion (see ENVIRONMENTAL REQUIREMENTS section for spawning temperatures). The timing of offshore spawning migrations apparently is a southward progression of a cycle that begins in the northern part of the Middle Atlantic Bight in early September and ends in the South Atlantic Bight by December (Eldridge 1962; Smith 1973; Morse 1981). Powell (1974) noted peak gonadal development during December and January for individuals collected from the Cape Hatteras area; and all fish collected during April and May at Beaufort, North Carolina, were spent (Hildebrand and Schroeder 1928). Therefore, a progressively later peak of spawning activity is likely for the South Atlantic Bight, starting in mid- to late-November in the Cape Hatteras area and ending in early spring in south Georgia and Florida. There is good evidence to indicate that summer flounder are serial spawners, continuously shedding mature eggs during the protracted spawning season (Morse 1981). It is likely that year-to-year variation in migratory distances is governed by variation in the extent to which coastal waters are cooled each winter. Morse (1981) suggested that "the reproductive strategy of the summer flounder tends to maximize reproductive potential and avoid catastrophe" by combining a protracted spawning season of variable duration with early maturation, high fecundity, serial spawning, and extensive migrations across the shelf.

Adult summer flounder move inshore after spawning in late spring and show peak abundance in coastal waters from July to September. Individuals in Middle Atlantic stocks tend to use the same spawning and wintering areas in successive years, but similar behavior has not been documented for stocks in the South Atlantic Bight. This behavior provides a mechanism by which adjacent stocks can be reproductively isolated (Wilk et al. 1980; see THE FISHERY section). Tagging studies in the Middle Atlantic Bight indicate a tendency for older and larger fish to move toward the northeastern limit of the fishery's range.

Fecundity

Powell (1974) reported values of 1,670,000 to 1,700,000 ova/fish for three females ranging from 506 to 682 mm total length (TL). Morse (1981) estimated 463,000 to 4,188,000 ova/fish for fish between 366 and 680 mm TL and gave the following equations for the estimation of fecundity (F is ova/fish):

$$\log_{10}F = -3.098 + 3.402 \log_{10}L$$

$$r^2 = 0.77; \text{ and}$$

$$F = 101,867.5 + 908.864\ W,$$

$$r^2 = 0.76;$$

where L = total length in cm and W = wet body weight in g.

Eggs and Larvae

Eggs of the summer flounder are pelagic and have been observed to hatch 2 to 9 days after fertilization under experimental conditions at temperatures of 21°C down to 5°C (Johns and Howell 1980; Johns et al. 1981). Lengths at hatching were 2.83 to 3.16 mm SL (Johns et al. 1981). Yolk-sac absorption is complete at about 3.6 mm SL, and Johns et al. (1981) indicated that this length was reached at approximately 5.7 days after hatching at 11°C or 2.8 days at 21°C. At this point, the eyes are pigmented, the mouth is functional, and the digestive tract is complete (Johns et al. 1981).

Feeding habits of larvae and postlarvae have not been described in detail. Peters and Angelovic (1971) reared postlarvae on a diet of zooplankton (mostly copepods) and Artemia nauplii.

Williams and Deubler (1968) stated that larvae shorter than 7 mm SL depend on currents for dispersal; however, there are no data that describe relationships between recruitment to nursery areas and wind-driven (Ekman) transport or prevailing directions of water flow. Larval flounder have been collected inshore earlier in years with mild winters than in years with severe winters (Cain and Dean 1976; Bozeman and Dean 1980). Dispersal in areas having strong tidal currents is accomplished by diel vertical migrations that result in tidal transport (Weinstein et al. 1980b).

Juveniles and Adults

Young summer flounder first move into estuaries at about 7 mm SL from February through April (Weinstein et al. 1980b) and are 9 to 16 mm SL during peak recruitment in the Cape Fear River Estuary, North Carolina (Weinstein 1979; Weinstein et al. 1980a). Other studies in the South Atlantic Bight report lengths at first capture from inshore locations that range from 11 to 36 mm TL during January through May (Tagatz and Dudley 1961; Miller and Jorgenson 1969; Burns 1974; Cain and Dean 1976; Bozeman and Dean 1980). Some variations among lengths and times at which larvae have been observed to move into estuaries probably are due to differences in sampling gear.

Postlarval summer flounder (10 to 18 mm SL) were captured most frequently at salinities exceeding 7.4 parts per thousand (ppt) in the Cape Fear River Estuary (Weinstein et al. 1980a). Keup and Bayless (1964) did not capture summer flounder from locations in the Neuse River basin, North Carolina, at salinities below 12 ppt. Turner and Johnson (1973) reported that summer flounder of all ages occurred in the Newport River, North Carolina, at salinities of 3 to 33 ppt. Juveniles longer than 18 mm SL were found in greatest abundance at salinities exceeding 12 ppt over sandy substrates in Pamlico Sound, North Carolina (Powell and Schwartz 1977). Adams (1976a) reported the occurrence of juvenile summer flounder in eel grass (Zostera marina) meadows near Beaufort, North Carolina, during the summer. Orth and Heck (1980) indicated that summer flounder also used shallow vegetated areas during daylight in Chesapeake Bay. The relative importance of different estuarine habitat types to young summer flounder requires further study.

Estuarine areas from Connecticut (Poole 1966) to Georgia provide nursery habitat for summer flounder (Miller and Jorgenson 1969). Several authors, however, have suggested that the primary nursery grounds are Virginia's eastern shore, Chesapeake Bay, and the sounds of North Carolina (Deubler 1958; Pearcy and Richards 1962; Poole 1966; Powell and Schwartz 1977).

Young flounder generally emigrate from North Carolina's estuarine waters during their second fall of life (Powell and Schwartz 1977), but this emigration may occur earlier in the north (Poole 1966). Some individuals of a given year class probably remain in Pamlico Sound, North Carolina, for 18 to 20 months following their arrival in the nursery area (Powell and Schwartz 1977).

Powell (1974) reported that flounder collected from Pamlico Sound, North Carolina, matured at about 350 mm TL. Lengths at maturity for flounder in the Middle Atlantic Bight ranged from 240 to 270 mm TL for males and 300 to 330 mm TL for females (Morse 1981). The smallest mature male was 190 mm TL, and the largest immature male was 440 mm TL. Corresponding values for females were 250 mm TL and 440 mm TL. Additional information is available for the Middle Atlantic Bight (Eldridge 1962; Smith and Daiber 1977), but none exists for the South Atlantic Bight. Fish as small as 130 mm TL, however, can be found in shelf waters where mature fish have migrated offshore to spawn during the fall and winter (Wilk and Silverman 1976).

GROWTH CHARACTERISTICS

Considerable controversy exists regarding the validity of using otoliths to age summer flounder (Poole 1961; Eldridge 1962; Powell 1974; Smith and Daiber 1977; Smith et al. 1981). Authors have variously stated that the first "annulus" forms at ages II through VII, indicating that length-at-age information is subject to considerable error. Only one growth study (Powell 1974) has been done in the South Atlantic Bight (at Pamlico Sound). Powell showed that growth began in the spring and ended in the fall as the water temperature reached an approximate 7°C threshold. Flounder were 111 to 219 mm TL at the end of their first growing season. Maximum sizes of males collected from New York were about 600 mm TL and 2200 g, and females reached 800 mm and 5500 g (Poole 1966). Summer flounder may live about 10 years; all fish older than 7 years of age collected by Eldridge (1962) were females. Growth rates published for fish collected outside the South Atlantic Bight were summarized by Smith et al. (1981).

No information on larval and postlarval growth under natural conditions exists. Effects of temperature, salinity, and food availability on larval and juvenile growth have been investigated in laboratories (see ENVIRONMENTAL REQUIREMENTS section). Length-weight relationships for fishes in Pamlico Sound, North Carolina, and the Middle Atlantic Bight are in Table 1. Seasonal and sex-specific differences in length-weight relationships occur in the Middle Atlantic Bight (Eldridge 1962; Lux and Porter 1966; Wilk et al. 1978; Morse 1981), but no data exist to evaluate these relationships for the South Atlantic Bight.

Table 1. Weight-length regressions for summer flounder, where $\log_{10}$ weight (g) = a + b $\log_{10}$ length (mm) and r = correlation coefficient.

Location/source	a	b	r
Pamlico Sound, North Carolina (Powell 1974)	-5.254	3.099	0.99
Middle Atlantic Bight (Wilk et al. 1978)			
Males	-5.289	3.126	0.96
Females	-5.578	3.226	0.98

THE FISHERY

History

The commercial summer flounder fishery in the South Atlantic Bight consists of an offshore otter trawl fishery in the Cape Hatteras area and small incidental catches associated with shrimp trawling throughout the region. There is no fishery for summer flounder throughout most of the open shelf waters of the South Atlantic Bight. The Cape Hatteras winter trawl fishery was initiated in the late 1920's as trawlers from northern ports moved south to exploit flounders and other species (Pearson 1932). Fishing occurs during two major time periods. Trawling effort is concentrated north of Cape Hatteras from November through late December ("fall") in waters 40 to 100 m deep and just south of Cape Hatteras from December through March or April ("winter") in waters 20 to 60 m deep (Pearson 1932). About 60% of the annual North Carolina flounder landings occur during the fall fishery (outside of the South Atlantic Bight), and 20% is taken from the northern limit of the South Atlantic Bight during the winter fishery, according to the U. S. Department of Commerce (USDC), National Marine Fisheries Service (1978, 1980a).

Total annual landings for 1974 through 1978 in North Carolina averaged about 18.5 million lb, valued at \$9.7 million (USDC 1980b). Harvest and economic value for other parts of the South Atlantic Bight have not been reported, probably because abundance elsewhere is too low to support a major commercial fishery.

The recreational catch of summer flounder in the South Atlantic Bight is minor compared to catches in the Middle Atlantic and Gulf of Mexico regions. Numbers caught (in 1000's) by anglers in 1979 were: Middle Atlantic region - 12,653; Gulf of Mexico - 1,882; South Atlantic - 988; and North Atlantic - 571 (USDC 1980c). The South Atlantic catch was comprised of 72% from North Carolina, 19% from Florida, 7% from South Carolina, and 2% from Georgia.

No information exists on the age and size composition of the summer flounder catch in the South Atlantic Bight. The commercial and recreational catch in the Middle Atlantic Bight consists mostly of fish younger than age V (Poole 1961; Eldridge 1962).

Management

No accounts of biological parameters needed for management of summer flounder have been published for South Atlantic Bight. Scarlett (1982) listed several unpublished works that dealt with these problems for the Middle Atlantic Bight, and Poole (1962) made some recommendations for that region. The uncertain importance of Pamlico Sound, North Carolina, as a nursery area and the lack of age- or size-specific data on summer flounder distribution indicate a need for further investigation of summer flounder biology (Poole 1966). Recent evidence indicates distinct Middle and South Atlantic stocks (see below) and suggests that the North Carolina winter trawl fishery may exploit two stocks that are reproductively isolated.

Subpopulations

Since a genetically distinct stock can have unique rates of recruitment, growth, and mortality (Cushing 1968), identification of the stocks (= subpopulations) and stock-specific biological traits is necessary for proper management. Ginsburg (1952) and Smith and Daiber (1977) provided evidence suggesting the existence of separate stocks of summer flounder in North Carolina and in the Chesapeake-Delaware Bay areas. Smith (1973) proposed the existence of three spawning populations (New York/New Jersey; Delaware Bay to Cape Hatteras;

Cape Hatteras to Cape Lookout). Wilk et al. (1980) demonstrated significant differences in meristic and morphometric characteristics of summer flounder collected in the Middle and South Atlantic Bights and showed little intermixing between the groups. They concluded that individuals from both groups use the Pamlico Sound estuarine complex as a nursery area, but use separate spawning grounds each winter.

ECOLOGICAL ROLE

The larval and postlarval feeding ecology of summer flounder is not well documented; it is only inferred that they initially feed on zooplankton and then utilize small crustaceans (Peters and Angelovic 1971; Powell 1974; Morse 1981). Juveniles longer than 80 mm in Pamlico Sound consumed progressively larger prey items as they grew (Powell and Schwartz 1979). They initially fed on mysid shrimp and small fish and shifted to decapod crustaceans and larger fish as they reached adulthood.

No data exist for other areas in the South Atlantic Bight, but adults north of Cape Hatteras feed primarily on fish and large invertebrates in estuaries and shelf waters (Ginsburg 1952; Bigelow and Schroeder 1953; Poole 1964; Langton and Bowman 1981). Olla et al. (1972) showed that summer flounder are visual feeders and are adept at feeding on the bottom and in the water column. Laboratory studies (Olla et al. 1972) and field collections (Orth and Heck 1980) indicate that summer flounder are active primarily during daylight hours.

The role of summer flounder in ecosystem function and community dynamics has not been adequately addressed, but the adults are generally regarded as top or nearly top predators. Because the flounder undergoes pronounced seasonal migrations, its influences on prey populations and its interactions with other predatory species are expected to vary with season, depth, and habitat type. Summer flounder are spatially separated from congeners in Pamlico Sound (Powell and Schwartz 1977), but interactions with other species or populations apparently have not been studied.

Paralichthys spp. in the eelgrass communities near Beaufort, North Carolina, collectively accounted for about 1% of the annual production and respiration of the fish assemblage (Thayer and Adams 1975; Adams 1976b). Orth and Heck (1980) indicated that summer flounder also used similar shallow vegetated areas in the Chesapeake Bay system. These data indicate that grass bed habitats are important to the summer flounder, and any loss of these areas along the Atlantic seaboard may affect flounder stocks.

ENVIRONMENTAL REQUIREMENTS

Temperature, Salinity, and Dissolved Oxygen

Summer flounder tolerate a wide range of physical and chemical conditions, but many aspects of the species' biology are significantly influenced by such factors. Johns and Howell (1980) and Johns et al. (1981) showed that increased temperature within a range of 5° to 21°C promoted faster development of embryos and yolk-sac larvae. Temperatures below 11°C were lethal to larvae during development, but at higher temperatures all larvae were the same length at yolk-sac absorption. Data for the Middle Atlantic Bight and Cape Hatteras areas indicate that adults spawn where bottom water temperatures are 12° to 19°C, but most eggs were collected where temperatures were 18° to 19°C (Smith 1973). Some evidence indicates that the offshore limits of migration (Nesbit and Neville 1935) and spawning (Smith 1973) of summer flounder in the Middle Atlantic Bight coincide with the inshore edge of the mass of cold bottom water, but it is not known if this relationship exists in the South Atlantic Bight. Smith (1973) proposed that temperature changes caused by mixing of the cold water with upper layers during late summer and fall storms affected year-class success in the Middle Atlantic Bight. Temperature has a pronounced effect on growth efficiency, feeding rate, and assimilation efficiency of juveniles held in laboratory conditions (Peters and Angelovic 1971).

Juvenile flounder in estuarine areas occur throughout a wide range of salinities (see LIFE HISTORY section), but laboratory studies have shown that growth rates increase with increasing salinity (Deubler and White 1962; Peters and Angelovic 1971). Maximum growth rate and efficiency occurred at salinities greater than 10 ppt, corresponding with salinities at which young summer flounder are most abundant in estuaries.

Effects of dissolved oxygen concentration on summer flounder has not been investigated, but the closely related southern flounder (*Paralichthys lethostigma*) prefers water with dissolved oxygen concentrations exceeding 3.7 ml/l (or 5.3 mg/l) (Deubler and Posner 1963).

Substrate and Vegetation

Juvenile summer flounder occur more frequently over sandy substrates than mud or silt bottoms in Pamlico Sound, North Carolina (Turner and Johnson 1979). During daylight hours, the fish tend to occupy areas in estuaries that have submerged vegetation (Adams 1976a; Orth and Heck 1980). The LIFE HISTORY section includes information on factors that may govern flounder migrations and effects of water movement on transport of young. Effects of turbidity have not been reported.

Environmental Contaminants

Arsenic, copper, and zinc residues were somewhat high in summer flounder collected in the South Atlantic Bight, but information on acceptable or safe levels of these trace metals was not reported (Hall et al. 1978). Mean and maximum values for mercury concentrations were below United States Food and Drug Administration "action" levels. Certain polynuclear aromatic hydrocarbons were detected at low levels in summer flounder collected from the Baltimore Canyon in the Middle Atlantic Bight (Brown and Pancirov 1979). Toxic levels of most contaminants to summer flounder have not been quantified.

LITERATURE CITED

Adams, S. M. 1976a. The ecology of eelgrass, Zostera marina (L.), fish communities. I. Structural analysis. J. Exp. Mar. Biol. Ecol. 22:269-291.

Adams, S. M. 1976b. The ecology of eelgrass, Zostera marina (L.), fish communities. II. Functional analysis. J. Exp. Mar. Biol. Ecol. 22:293-311.

Anderson, W. W. 1968. Fishes taken during shrimp trawling along the South Atlantic coast of the United States, 1931-35. U. S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 570. 60 pp.

Anderson, W. W., and J. W. Gehringer. 1965. Biological-statistical census of the species entering fisheries in the Cape Canaveral area. U. S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 514. 79 pp.

Bigelow, H. B., and W. C. Schroeder. 1953. Fishes of the Gulf of Maine. U. S. Fish Wildl. Serv. Fish. Bull. 53:577 pp.

Bozeman, E. L., and J. M. Dean. 1980. The abundance of estuarine larval and juvenile fish in a South Carolina intertidal creek. Estuaries 3:89-97.

Brown, R. A., and R. J. Pancirov. 1979 Polynuclear aromatic hydrocarbons in Baltimore Canyon fish. Environ. Sci. Technol. 13:878-879.

Burns, R. W. 1974. Seasonal abundance and diversity of larval fishes in a high-marsh tidal creek. M.S. Thesis. University of South Carolina, Columbia. 54 pp.

Cain, R. E., and J. M. Dean. 1976. Annual occurrence, abundance and diversity of fish in a South Carolina intertidal creek. Mar. Biol. (Berl.) 36:369-379.

Cushing, D. H. 1968. Fisheries biology, a study in population dynamics. University of Wisconsin Press, Madison. 200 pp.

Dahlberg, J. D., and E. P. Odum. 1970. Annual cycles of species occurrence, abundance, and diversity in Georgia estuarine fish populations. Am. Midl. Nat. 83:382-392.

Deubler, E. E., Jr. 1958. A comparative study of the postlarvae of three flounders (Paralichthys) in North Carolina. Copeia 1958:112-116.

Deubler, E. E., Jr., and G. S. Posner. 1963. Response of postlarval flounders, Paralichthys lethostigma, to water of low oxygen concentrations. Copeia 1963:312-317.

Deubler, E. E., Jr., and J. C. White, Jr. 1962. Influence of salinity on growth of postlarvae of the summer flounder, Paralichthys dentatus. Copeia 1962:468-469.

Eldridge, P. J. 1962. Observations on

the winter trawl fishery for summer flounder, Paralichthys dentatus. M.S. Thesis. College of William and Mary, Williamsburg, Va.

Ginsburg, I. 1952. Flounders of the genus Paralichthys and related genera in American waters. U. S. Fish Wildl. Serv. Fish. Bull. 52:267-351.

Gutherz, E. J. 1967. Field guide to the flatfishes of the family Bothidae in the Western North Atlantic. U. S. Fish Wildl. Serv. Bur. Comm. Fish. Circ. 263. 47 pp.

Hall, R. A., E. G. Zook, and G. M. Meaburn. 1978. National Marine Fisheries Service surveys of trace elements in the fishery resource. U. S. Dep. Commer. Natl. Mar. Fish. Serv. Spec. Sci. Rep. Fish. 721. 313 pp.

Hildebrand, S. F., and W. C. Schroeder 1928. Fishes of Chesapeake Bay. Bull. U. S. Bur. Fish. 43, Part 1. 366 pp.

Johns, D. M., and W. H. Howell. 1980. Yolk utilization in summer flounder (Paralichthys dentatus) embryos and larvae reared at two temperatures. Mar. Ecol. Prog. Ser. 2:1-8.

Johns, D. M., W. H. Howell, and G. Klein-MacPhee. 1981. Yolk utilization and growth to yolk-sac absorption in summer flounder (Paralichthys dentatus) larvae at constant and cyclic temperatures. Mar. Biol. (Berl.) 63:301-308.

Keup, L., and J. Bayless. 1964. Fish distribution at varying salinities in Neuse River basin, North Carolina. Chesapeake Sci. 5:119-123.

Langton, R. W., and R. E. Bowman. 1981. Food of eight Northwest Atlantic pleuronectiform fishes. U. S. Dep. Commer. Natl. Mar. Fish. Serv. Spec. Sci. Rep. Fish. 749. 16 pp.

Leim, A. H., and W. B. Scott. 1966. Fishes of the Atlantic coast of Canada. Fish. Res. Board Can. Bull. 155. 485 pp.

Lux, F. E., and F. E. Nichy. 1981. Movements of tagged summer flounder, Paralichthys dentatus, off southern New England. U. S. Dep. Commer. Natl. Mar. Fish. Serv. Spec. Sci. Rep. Fish. 752. 16 pp.

Lux, F. E., and L. R. Porter, Jr. 1966. Length-weight relation of the summer flounder, Paralichthys dentatus (Linnaeus). U. S. Fish. Wildl. Serv. Spec. Sci. Rep. Fish. 531. 5 pp.

Martin, F. D., and G. E. Drewry. 1978. Development of fishes of the MId-Atlantic Bight, an atlas of egg, larval, and juvenile stages. Vol. VI, Stromateidae through Ogocephalidae. U. S. Fish. Wildl. Serv. Biol. Serv. Program FWS/OBS-78/12. 416 pp.

Miller, G. L., and S. C. Jorgenson. 1969. Seasonal abundance and length frequency distributions of some marine fishes in coastal Georgia. U. S. Fish Wildl. Serv. Data Rep. 35. 102 pp.

Morse, W. W. 1981. Reproduction of the summer flounder, Paralichthys dentatus (L.). J. Fish Biol. 19:189-203.

Murawski, W. S. 1970. Results of tagging experiments of summer flounder, Paralichthys dentatus, conducted in New Jersey waters from 1960 to 1967. N. J. Dep. Environ. Protect. Bur. Fish. Misc. Rep. 5M. 52 pp.

Nesbit, R. A., and W. C. Neville.

1935. Conditions affecting the southern winter trawl fishery. U. S. Bur. Fish. Fish. Circ. 18. 12 pp.

Olla, B. L., C. E. Sameet, and A. L. Studhome. 1972. Activity and feeding behavior of the summer flounder (*Paralichthys dentatus*) under controlled laboratory conditions. U. S. Natl. Mar. Fish. Serv. Fish. Bull. 70:1127-1136.

Orth, R. J., and K. L. Heck, Jr. 1980. Structural components of eelgrass (*Zosteria marina*) meadows in the lower Chesapeake Bay - fishes. Estuaries 3:278-288.

Pearcy, W. G., and S. W. Richards. 1962. Distribution and ecology of fishes in the Mystic River Estuary, Connecticut. Ecology 43:248-259.

Pearson, J. C. 1932. Winter trawl fishery off the Virginia and North Carolina coasts. U. S. Bur. Fish. Invest. Rep. 10. 31 pp.

Peters, D. S., and J. W. Angelovic. 1971. Effect of temperature, salinity, and food availability on growth and energy utilization of juvenile summer flounder, *Paralichthys dentatus*. Pages 545-554 *in* D. J. Nelson, ed. Radionuclides in ecosystems. National Symposium on Radioecology, Oak Ridge, Tenn.

Poole, J. C. 1961. Age and growth of the fluke in Great South Bay and their significance to the sport fishery. N. Y. Fish Game J. 8:1-18.

Poole, J. C. 1962. The fluke population of Great South Bay in relation to the sport fishery. N. Y. Fish Game J. 9:93-117.

Poole, J. C. 1964. Feeding habits of the summer flounder in Great South Bay. N. Y. Fish Game J. 11:28-34.

Poole, J. C. 1966. A review of research concerning summer flounder and needs for further study. N. Y. Fish Game J. 13:226-231.

Powell, A. B. 1974. Biology of the summer flounder, *Paralichthys dentatus*, in Pamlico Sound and adjacent waters, with comments on *P. lethostigma* and *P. albigutta*. M.S. Thesis. University of North Carolina, Chapel Hill. 145 pp.

Powell, A. B., and F. J. Schwartz. 1977. Distribution of paralichtid flounders (Bothidae: *Paralichthys*) in North Carolina estuaries. Chesapeake Sci. 18:334-339.

Powell, A. B., and F. J. Schwartz. 1979. Food of *Paralichthys dentatus* and *P. lethostigma* (Pisces:bothidae) in North Carolina estuaries. Estuaries 2:276-279.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada. Am. Fish. Soc. Spec. Publ. 12. 174 pp.

Scarlett, P. G. 1982. Annotated bibliography and subject index on the summer flounder, *Paralichthys dentatus*. U. S. Dep. Commer. Natl. Mar. Fish. Serv. Spec. Sci. Rep. Fish. 755. 12 pp.

Smith, R. W., and F. C. Daiber. 1977. Biology of the summer flounder, *Paralichthys dentatus*, in Delaware Bay. U. S. Natl. Mar. Fish. Serv. Fish. Bull. 75:823-830.

Smith, R. W., L. M. Dery, P. G. Scarlett, and A. Jearld, Jr. 1981. Proceedings of the summer flounder (*Paralichthys dentatus*) age and growth workshop. U. S. Dep. Commer., NOAA Tech. Memo, NMFS-F/NEC-11. 30 pp.

Smith, W. G. 1973. The distribution of summer flounder, *Paralichthys dentatus*, eggs and larvae on the Continental Shelf between Cape Cod and Cape Lookout, 1965-1966. U. S. Natl. Mar. Fish. Serv. Fish. Bull. 71:527-548.

Tagatz, M. E., and G. L. Dudley. 1961. Seasonal occurrence of marine fishes in four shore habitats near Beaufort, North Carolina, 1957-1960. U. S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 390. 19 pp.

Thayer, G. W., and S. M. Adams. 1975. Structural and functional aspects of a recently established *Zostera marina* community. Pages 518-540 *in* L. E. Cronin, ed., Estuarine research, Volume I. Academic Press, New York.

Topp, R. W., and F. H. Hoff, Jr. 1972. Flatfishes (Pleuronectiformes). Mem. Hourglass Cruises 4:135 pp.

Turner, W. R., and G. N. Johnson. 1973. Distribution and relative abundance of fishes in Newport River, North Carolina. U. S. Natl. Mar. Fish. Serv. Spec. Sci. Rep. Fish. 666. 23 pp.

U. S. Department of Commerce (USDC), National Marine Fisheries Service. 1978. Fishery statistics of the United States, 1975. Stat. Digest 69. 418 pp.

U. S. Department of Commerce (USDC), National Marine Fisheries Service. 1980a. Fishery statistics of the United States, 1976. Stat. Digest 70. 419 pp.

U. S. Department of Commerce (USDC), National Marine Fisheries Service. 1980b. Fishery statistics of the United States, 1979. U. S. Natl. Mar. Fish. Serv. Curr. Fish. Stat. No. 8000. 131 pp.

U. S. Department of Commerce (USDC), National Marine Fisheries Service. 1980c. Marine recreational fishery statistics survey, Atlantic and Gulf Coasts, 1979. U. S. Natl. Mar. Fish. Serv. Curr. Fish. Stat. No. 8063. 120 pp.

Weinstein, M. P. 1979. Shallow marsh habitats as primary nurseries for fishes and shellfishes, Cape Fear River, North Carolina. U. S. Natl. Mar. Fish. Serv. Fish. Bull. 77:339-357.

Weinstein, M. P., S. L. Weiss, and M. F. Walters. 1980a. Multiple determinants of community structure in shallow marsh habitats, Cape Fear River Estuary, North Carolina. USA. Mar. Biol. (Berl.) 58:227-243.

Weinstein, M. P., S. L. Weiss, R. G. Hodson, and L. R. Gerry. 1980b. Retention of three taxa of postlarval fishes in an intensively flushed tidal estuary, Cape Fear River, North Carolina. U. S. Natl. Mar. Fish. Serv. Fish. Bull. 78:419-436.

Wenner, C. A., C. A. Barans, B. W. Stender, and F. H. Berry. 1979a. Results of MARMAP otter trawl investigations in the South Atlantic Bight. I. Fall. 1973. S. C. Mar. Resour. Center Tech. Rep. 33. 79 pp.

Wenner, C. A., C. A. Barans, B. W. Stender, and F. H. Berry. 1979b. Results of MARMAP otter trawl investigations in the South Atlantic Bight. II. Spring,

1974. S. C. Mar. Resour. Cent. Tech. Rep. 41. 62 pp.

Wenner, C. A., C. A. Barans, B. W. Stender, and F. H. Berry. 1979c. Results of MARMAP Otter trawl investigations in the South Atlantic Bight. III. Summer, 1974. S. C. Mar. Resour. Cent. Tech. Rep. 44. 59 pp.

Wenner, C. A., C. A. Barans, B. W. Stender, and F. H. Berry. 1979d. Results of MARMAP otter trawl investigations in the South Atlantic Bight. IV. Winter-early spring, 1975. S. C. Mar. Resour. Cent. Tech. Rep. 44. 59 pp.

Wenner, C. A., C. A. Barans, B. W. Stender, and F. H. Berry. 1980. Results of MARMAP otter trawl investigations in the South Atlantic Bight. V. Summer, 1975. S. C. Mar. Resour. Cent. Tech. Rep. 45. 57 pp.

Wilk, S. J., and M. J. Silverman. 1976. Fish and hydrographic collections made by the research vessels *Dolphin* and *Delaware* II during 1968-72 from New York to Florida. U. S. Dep. Commer. Natl. Mar. Fish. Serv. Spec. Sci. Rep. Fish. 697. 159 pp.

Wilk, S. J., W. W. Morse, and D. E. Ralph. 1978. Length-weight relationships of fishes collected in the New York Bight. Bull. N. J. Acad. Sci. 23:58-64.

Wilk, S. W., W. G. Smith, D. E. Ralph, and J. Sibunka. 1980. Population structure of summer flounder between New York and Florida based on linear discriminant analysis. Trans. Am. Fish. Soc. 109-265-271.

Williams, A. B., and E. E. Deubler. 1968. A ten-year study of meroplankton in North Carolina estuaries: assessment of environmental factors and sampling success among bothid flounders and penaeid shrimps. Chesapeake Sci. 9:27-41.

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries on the taxonomy, morphology, distribution, life history, and environmental requirements of coastal aquatic invertebrates and fishes. They are designed to assist with environmental impact assessment. The summer flounder, Paralichthyes dentatus, is an important commercial and recreational fish along the Atlantic seaboard of the United States. Adult summer flounder are migratory and prey on other fishes and invertebrates. They spawn in offshore shelf waters during late fall, winter, and early spring, and larvae move to inshore nursery areas during late winter and spring. Juveniles are found in a variety of habitats where salinities generally exceed 10 ppt, and the young may remain in estuarine nusery areas for as long as 20 months before participating in seasonal offshore migrations. Adults may live 10 years and generally are found in nearshore areas during late spring, summer, and early fall. The influences of temperature, salinity, and substrate on summer flounder are not well documented. Juveniles grow fastest at salinities above 10 ppt and they appear to prefer sandy substrates rather than mud or silt bottoms. They species may undergo diel movements to areas having submerged vegetation during daylight.

17. Document Analysis a. Descriptors
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Paralichthys dentatus
Spawning
Salinity requirements
Substrate requirements

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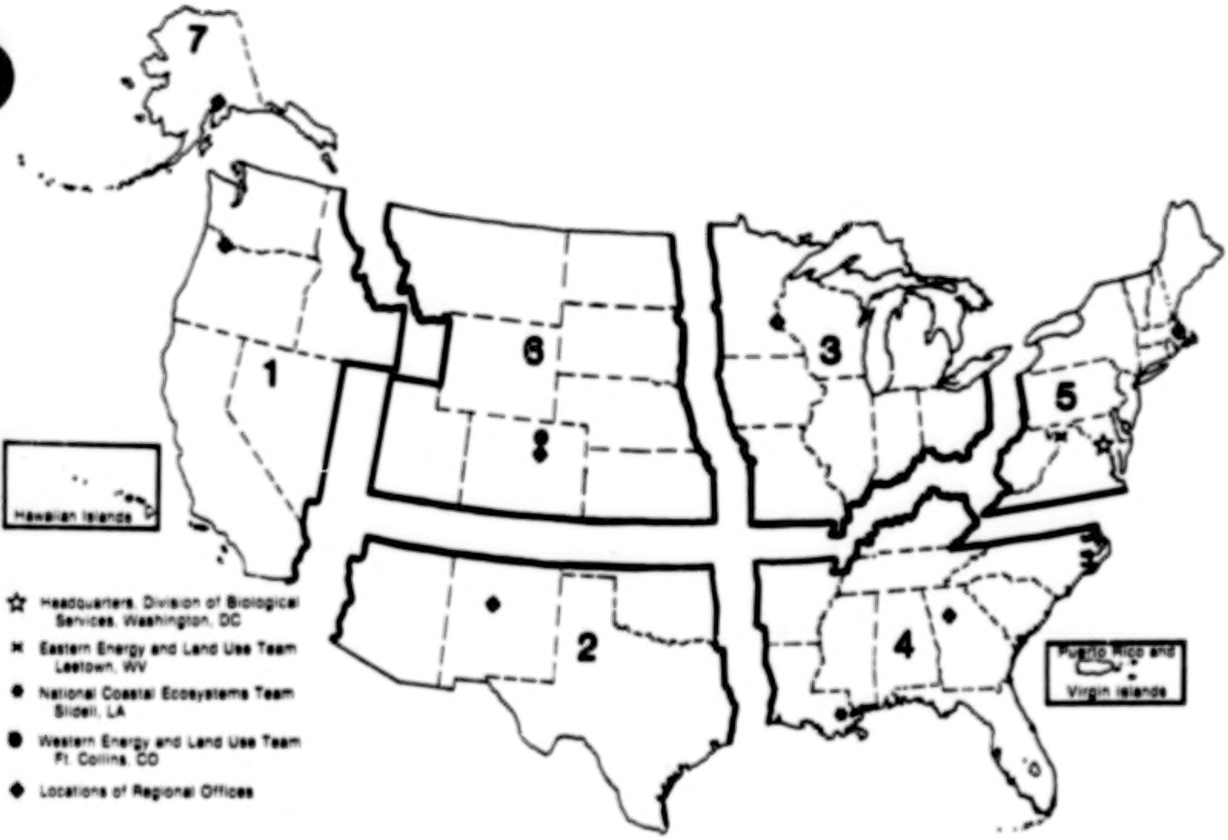
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